Studies of Nuclei at Extreme Deformations

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The search for hyperdeformed (HD) shapes has been a goal of nuclear structure for many years. As an extreme limit, hyperdeformed nuclei have a prolate deformation corresponding to an axis ratio of c/a = 3. In this same limit, based on a simple harmonic oscillator potential, superdeformed (SD) nuclei have c/a = 2, and both HD and SD shapes are favored due to symmetries associated with integer axis ratios. Realistic nuclear potentials modify this simple picture and SD nuclei have axis ratios in the range c/a~1.6 to 1.8. Similarly we may expect HD nuclei to exhibit c/a <3.

In general, each distinct prolate shape (whether normal, super-, or hyperdeformed) can be correlated with the occupation of specific high-j intruder states (fig 1). Normal deformed nuclei correspond to the occupation of intruders from one major oscillator shell above the spherical shell (N+1, "*normal-intruders*"), SD nuclei can be correlated with the occupation of intruder states from two shells above (N+2, "*super-intruders*"), and HD nuclei involve intruder states from three shells above (N+3, "*hyper-intruders*"). Thus the key to observing HD nuclei may well lie in finding cases where N+3 intruders can be populated. Cadmium and Tin nuclei lie in a region where the N+3 *hyper-intruders* ($\pi i_{13/2}$ and $\nu j_{15/2}$) are calculated to approach the Fermi surface.

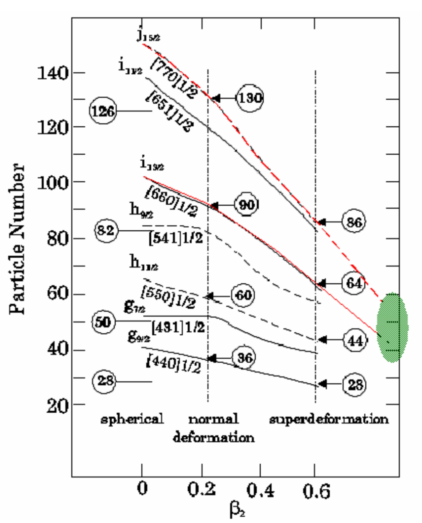

Fig 1 Occupation of intruders as a function of deformation.

Our observation [1,2] of very deformed rotational structures in ^{108}Cd provided evidence for the occupation $i_{13/2}$ proton *hyper-intruder* state and suggested that HD nuclei (with both $i_{13/2}$ proton and neutron $j_{15/2}$ *hyper-intruders* occupied) could be observed in this region. Motivated by this we carried out a high statistics experiment using Gammasphere to extend our studies to the most neutron rich Sn and Cd isotopes possible in order to observe bands where the $j_{15/2}$ *hyper-intruder* is occupied.

The experiment used Gammasphere [3] and the reactions ^{68}Zn(^{48}Ca,4n)^{112}Sn and ^{70}Zn(^{48}Ca,4n)^{114}Sn to study very high spin states. Beams were provided by the ATLAS facility at Argonne. Approximately 10^9 gamma-ray fold>5 events were obtained, for each reaction. These reactions closely matched the ^{64}Ni(^{48}Ca,4n)^{108}Cd reaction used in refs [1,2]. A comparison of experimental conditions is given the table. (Note, it is not possible to find a favorable beam target combination that will produce a more neutron rich Cd compound nucleus than $^{112}Cd_{64}$ at very high angular momentum; $^{112}Sn_{62}$ and $^{114}Sn_{64}$ have 2 and 4 extra neutrons compared with $^{108}Cd_{60}$).

Reaction	E_b (MeV)	$E_{compound}$ (MeV)	$l_{max}(\hbar)$
^{64}Ni(^{48}Ca,4n)^{108}Cd	207	97	80
^{68}Zn(^{48}Ca,4n)^{112}Sn	206	96	78
^{70}Zn(^{48}Ca,4n)^{114}Sn	202	97	80

The data were analyzed using triple gamma-ray coincidences and a search was carried out for discrete-line rotational bands with transition energy spacings appropriate for deformations ranging from c/a ~ 1.5 to c/a ~ 3. No evidence was found for any such deformed structures in either the ^{112}Sn or ^{114}Sn data sets. From comparison with the ^{108}Cd data set we estimate the present experiment was sensitive rotational cascades with an intensity of order 0.2%, or greater, of the 4n channel. In all cases the 4n channel carried ~15% of the fusion cross-section. A previous experiment focused on ^{106}Cd yielded the same null result.

The fact no very deformed structures were observed either in ^{112,114}Sn or ^{106}Cd is surprising, particularly because the *hyper-intruder* band in ^{108}Cd carries ~1% of the 4n flux. This intensity is "large" and comparable to that of SD bands in other regions where many neighboring nuclei exhibit superdeformation. In the present case it appears that the Z=48 ^{108}Cd bands are "uniquely" favored, and it is possible that the expected region of *hyper-intruder* (HD) nuclei may lie in the more neutron-rich Cd isotopes, e.g. ^{110}Cd or beyond.

REFERENCES

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